ANALYSIS

41(188), October 1, 2015

ISSN 2278–5469 EISSN 2278–5450

Discovery

Assessment of groundwater quality with special emphasis to fluoride contamination in and around Mandvi Taluka, Surat, Gujarat, India

Mayuri Prajapati[1], Namrata Jariwala[2], Agnihotri PG[3]

1.Research Scholar, Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, India; Email: mayuri.prajapati64@gmail.com

2.Assistant Professor, Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, India; Email: ndj@ced.svnit.ac.in

3.Assistant Professor, Department of Civil Engineering, Sardar Vallabhbhai National Institute of Technology, Surat, India, Email: pga@ced.svnit.ac.in

Publication History

Received: 13 July 2015

Accepted: 31 August 2015

Published: 1 October 2015

Citation

Mayuri Prajapati, Namrata Jariwala, Agnihotri PG. Assessment of groundwater quality with special emphasis to fluoride contamination in and around Mandvi Taluka, Surat, Gujarat, India. *Discovery*, 2015, 41(188), 102-108

ABSTRACT

Fluoride contamination in drinking water due to natural and anthropogenic behavior has been documented as one of the major problems in worldwide impressive a serious threat to human health. Fluoride in drinking water has an intense effect to teeth and bones. The BIS and WHO has been decided fluoride concentration up to 1-1.5 mg/L as a permissible limit for drinking. Concentration of fluoride in the level of 1.5-4mg/L result in dental fluorosis whereas with prolonged consumption at still higher fluoride concentrations (4-10mg/L) dental fluorosis leads to skeletal fluorosis. High fluoride concentrations in ground water occur widely in many parts of world. This present study is carried out with the objective of determining the locations for higher fluoride concentration in groundwater of different villages of Mandvi Taluka of Surat, Gujarat, India. The physico-chemical study of groundwater samples of 20 locations was done by collecting groundwater samples from different representative bore wells and Hand pumps. The ground water samples collected in clean polylab bottles and analyzed for 12 different parameters such as pH,

Temperature, Electrical conductivity (EC), Alkalinity (TH), Fluoride (F^-), Nitrate (NO_3^-), Total dissolved solids (TDS), Chloride (Cl^-), Sulphate (SO^-_4), Total hardness (TH), Ca-Hardness, Mg-Hardness, by using standard APHA Standard Methods for the Examination of water and wastewater Analysis. The data revealed considerable variations in the water samples with respect to fluoride. From the studied available data, groundwater concentration is shown to be highly variable and variations are seen between different villages within the same block. The fluoride concentration in the groundwater was found to vary between 0.82 to 4.17mg/L. It is also revealed hardness exceeded in 85 percent of the samples. It is, therefore, suggested to take up detailed water quality surveys and community awareness programs on water quality in Mandvi Taluka, Surat.

Keywords: Groundwater Contamination, Fluoride, Drinking water, Physico-chemical parameters.

1. INTRODUCTION

Water is the most valuable gift of nature, which is essential for sustaining life and is required in almost all the activities of man – i.e. drinking, irrigation, municipal use, and for recreation. The conservation and the use of water, therefore, form the main elements in the country's developmental planning. Groundwater forms the major source of drinking water in the rural areas of most of the developing nations in the world. Presence of high concentration of fluoride in groundwater is a major problem in many countries as it causes health related problems. Possible sources of fluoride in groundwater are weathering and leaching of fluoride bearing minerals from the basement granitic rocks of this region under alkaline environment. By nature, the granitic rocks of this area possess fluoride values greater than the world average content in granitic rocks.

An inventory of fluoride concentration in drinking groundwater is important to hold down spread of the disease fluorosis. Knowledge about the natural hydrological and geochemical processes as well as the associated anthropogenic effects on a groundwater resource is required for a complete systematic understanding of groundwater vulnerability to contamination. The fluoride concentration along with various chemical parameters in ground water samples was determined in these regions. Moreover, an attempt has been made to statistically correlate the concentrations of fluoride with the other measured parameters and the conditions affecting the ground water quality.

2. ENVIRONMENTAL OCCURRENCE GEOCHEMISTRY OF FLUORINE

Fluorine is one of the reactive of all the elements. It is , therefore, not found as fluorine in the environment. Being the most electronegative of all elements (Hem, 1989). it has a strong tendency to acquire a negative charge and form fluoride ion (F^-) in solution.Minerals which have F^- are fluorite , apatite, mica, amphiboles, clay and villauamite. Certain clay minerals (illite, chlorite, smectites) show good anion exchange media from which large amounts of F^- concentration can be generated (Boyle and chagnon, 1995). F^- thus forms mineral complexes with number of cations and some common mineral species of low solubility contain F^- (Hem,1989). Its concentration in natural waters depends on factors such as temperature, pH ,solubillity of F^- bearing minerals, anion exchange capacity of aquifer materials (OH^- for F^-), type of geological formation traversed by waters and the amount of time that water remains in contact with the formation (Apambire et al. 1997). In ground water, fluorine occurs as fluoride ions (F^-) which forms complexes with inorganic and organic compounds. F^- is realesed into aqueous during weathering process of rocks, minerals and through anthropogenic pollution. Solubility of F^- from F^- bearing minerals is relatively low under normal conditions but slow process of dissolution enchances leaching and F^- enrichment in groundwater (Hem,1989). Part of F^- may occur in ground water as a result of fluorite(CaF_2) dissolution . While computing the thermodynamics equilibrium in the groundwater system in contact with both calcite and fluorite, a combined stage is formed,From which it can be concluded the aqueous concentration are proportional to HCO_3^- concentration and pH values. Consequently, high F^- water is usually HCO_3^- dominated which favours the dissolution of F^- from soils and rocks. Therefore, water with high F^- concentration can form in the areas where alkaline, i.e. carbonate-containing , waters are in contact with high F^- bearing rocks. F^- concentrations are relatively independent of the water soluble components but noteworthy correlation exists between F^- and pH values. The F^- solubility in the soil is lowest in the pH range of 5.0-6.5 (Adriano, 1986). At the higher pH value, ionic exchange occur between F^- and OH^- ions (illite, chlorite, micas and amphiboles) resulting in increase of F^- concentration in groundwater.

3. DESCRIPTION OF STUDY AREA

Mandvi is a Taluka in Surat District of Gujarat State, India and lies on the banks of the Tapti River. It is around 61 kilometers east of Surat. Population of Mandvi is 1, 85,911 approximately. Mandvi Taluka is bounded by Vyara Taluka towards South, Valod Taluka towards South, Bardoli Taluka towards west, Mangrol Taluka towards North. There are three State highways passing through the

city. The Nature of soil is having deep black clayey soil in Mandvi Taluka. The average annual rain fall for the area is 67 inches. The coordinates of Mandvi Taluka is 21.15°N 73.18°E. It is too hot in summer. Mandvi summer highest day temperature is in between 30 ° C to 42° C. Total twenty villages were covered for the collection of water sampling and analysis. Figure 1 shows the sample locations map for Mandvi Taluka, Surat, Gujarat, India. Table 1 shows the Groundwater physico-chemical characteristics of Mandvi Taluka. The representation S1,S2…S20 represents locations Amalsadi, Amba, Antroli, Areth, Badtal, Dharampor, Federia, Gamtalav, Godavadi, Godsamba, Kachhayabori, Kharoli, Khedpur, Kolakui, Madhurkui, Naren,Puna, Rajputbori, Rupan, Togapur are representing respectively hand pump locations numbers in table 2.

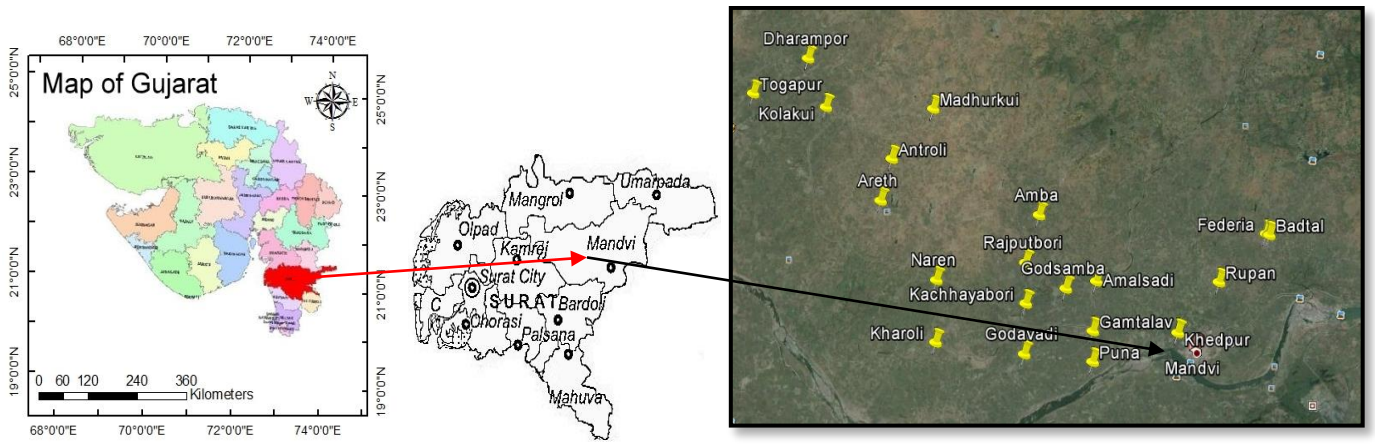

Figure 1 Location map of Mandvi Taluka, Surat, India

4. SAMPLE COLLECTION AND ANALYSIS

A total 20 ground water samples were collected from Mandvi Taluka of Surat district, Gujarat. Groundwater sampling locations were established in such a way that different physiographic regions, geological formations are represented and wells are more or less uniformly distributed in the study area. For assessment of groundwater quality it was ensured that the repeated measurements were made to ensure precision and accuracy of so as to arrive at meaningful and realistic analysis with reference to fluoride contamination in groundwater. The samples were collected in polylab pre-cleaned bottles of one litre capacity from hand-pumps after pumping out the volume of water standing in casing. pH, temperature and electrical conductivity (EC) were determined on the site using portable pH meter, temperature and EC meter. The water samples were collected from January to June, 2015. The water from these hand pumps were used for drinking, house hold utilities and bathing by the residents and public drinking water sources. All the reagents used were of analytical grade and solutions were made of distilled water. Analytical methods and equipment used in the study analysis of Physico- chemical characteristics of ground water samples are followed by APHA (1998), Standard Methods for Estimation of water and Wastewater, AWWA, Water Pollution Control Federation, New York, 19 (1995).

Table 1 Bureau of Indian Standards (BIS) for drinking water (IS 10500: 2012) and Methodology

Sr. No.	Parameters	Methodology	Indian Standard (IS;10500,2012)	
			Highest Desirable limit	Maximum permissible limit
1	pH	Electrometer	6.5-8.5	No relaxation
2	EC (µS/cm)	Electrometer	500	2000
3	Alkalinity (mg/L)	Titration Method	200	600
4	Sulphates (mg/L)	Turbidimetric	200	400
5	Chlorides (mg/L)	Argentometric Method	250	1000
6	Total hardness (mg/L)	EDTA Titrimetric Method	200	600

7	Ca Hardness (mg/L)	EDTA Titrimetric Method	75	200
8	Mg Hardness (mg/L)	EDTA Titrimetric Method	30	100
10	Nitrate (NO_3)mg/L	Spectrophotometry	45	No relaxation
11	Fluoride (mg/L)	SPADNS Method	1	1.5
12	TDS (mg/L)	Titration Method	500	2000

5. RESULTS AND DISCUSSIONS

The purpose of enlightening the water quality of samples locations have been established by determining the physical and chemical characteristics as per standard methods. They have been listed systematically and represented in table 2.The Physico-chemical property of analyzed water samples for Mandvi Taluka shows considerable variation in the water quality with respect to their chemical composition.

The groundwater was free from colour and odour and its taste was slightly salty at most of the locations. The temperature value ranges from 26.5°C to.31.5°C.The results also reveal that all the fluoride containing water samples were slightly inclined towards the alkaline side, with pH varying from 6.53 to 7.55 which is within the permissible limit i.e., 6.5 to 8.5 as per BIS :10500(2012). The alkalinity is mainly due to the bicarbonate ions which is clear from the absence of carbonate alkalinity. It varies from 202 mg/L (Federia) to 720 mg/L (Gamtalav) exceeding the permissible limits in all the samples. (Figure - 1 & 3)

Table 2 Groundwater physico-chemical characteristics of Mandvi Taluka, Surat

Sample No.	pH	EC µS/cm	Alkalinity mg/L	SO_4^{2-} mg/L	Cl^- mg/L	TH mg/L	Ca^{2+} mg/L	Mg^{2+} mg/L	NO_3^- mg/L	F^- mg/L	TDS mg/L
S1	7.27	1190	480	41.6	140.0	386	140	246	14.86	1.39	830
S 2	7.22	1459	400	54.8	329.9	370	160	210	7.11	1.32	1000
S 3	6.87	627	420	28.6	39.0	280	150	130	19.67	0.82	430
S 4	6.67	856	346	63.1	78.0	318	140	178	7.59	0.84	600
S 5	6.78	1129	346	494.1	193.4	425.5	219	206.5	61.77	1.19	829
S 6	6.92	1056	330	78.2	135.0	330	132	198	47.33	1.03	760
S 7	6.74	493.5	202	22.0	45.5	195	131	64	21.52	1.97	423
S 8	7.36	1222	720	19.7	125.5	340	126	214	3.89	1.12	833
S 9	7.26	838.5	349	43.6	71.5	341	151	190	34.00	1.26	566
S 10	7.55	777	458	25.7	46.2	262	149	113	4.28	0.92	570
S 11	7.55	894	349	25.6	45.3	173	88.7	84.3	9.10	1.11	587
S 12	6.96	820	334	39.7	69.0	318	220	98	19.95	1.08	570
S 13	7.41	830.75	448	14.9	60.0	178.5	123	55.5	24.41	1.24	571
S 14	7.22	1265	480	44.1	140.0	160	80	80	47.08	4.17	940
S 15	6.53	1902	326	134.9	391.9	990	420	570	120.42	0.91	1310
S 16	6.93	769	327	25.1	69.0	292	127	165	12.74	1.01	545
S 17	7.42	934	567	18.2	46.5	263	92	171	22.59	1.47	586
S 18	7.09	726	314	17.6	63.0	282	160	122	17.84	1.22	500
S 19	7.19	986	250	61.0	76.5	317	134	183	27.22	1.55	678
S 20	7.18	870	426	31.1	43.0	252	240	12	21.31	2.27	595

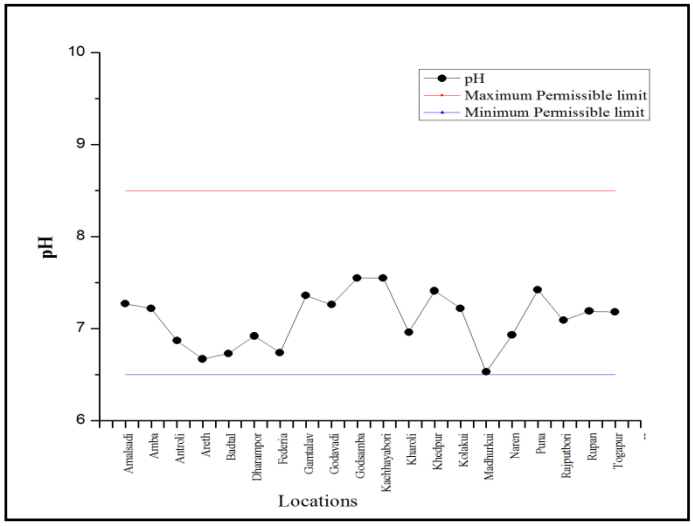

Figure 1 pH concentration at Mandvi Taluka

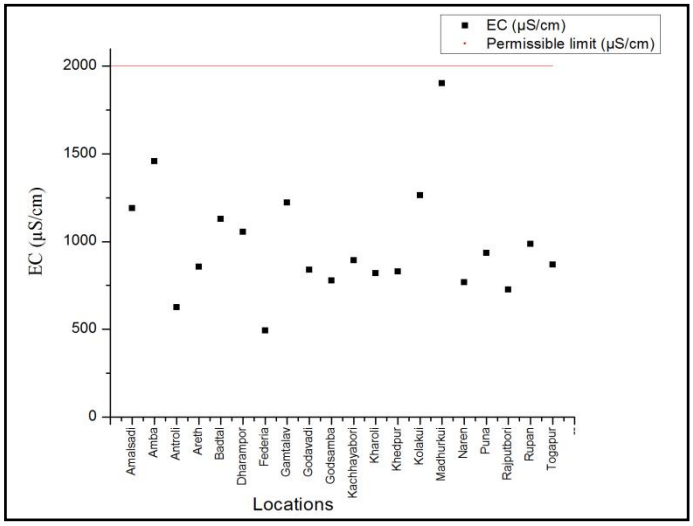

Figure 2 EC concentration at Mandvi Taluka

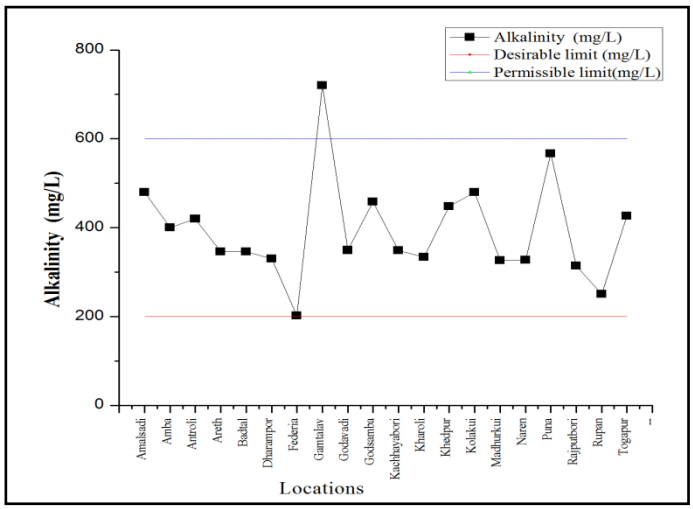

Figure 3 Alkalinity concentration at Mandvi Taluka

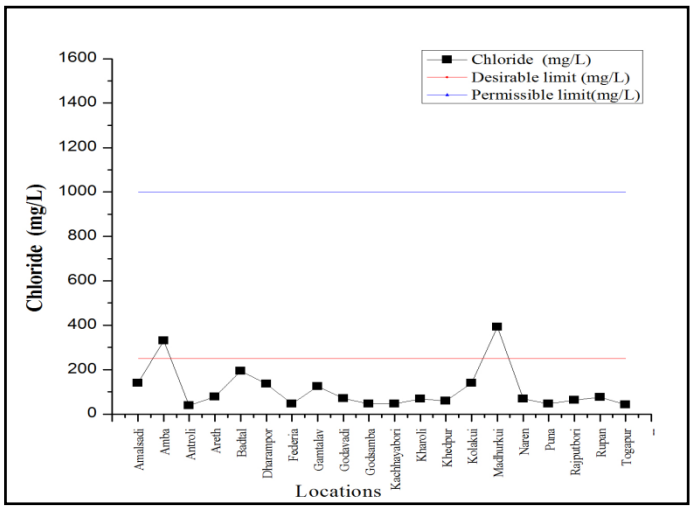

Figure 4 Chloride ion concentration at Mandvi Taluka

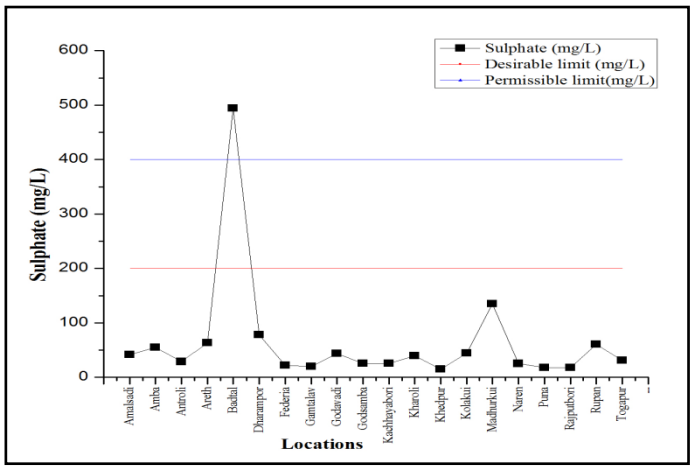

Figure 5 Sulphate ion concentrations at Mandvi Taluka

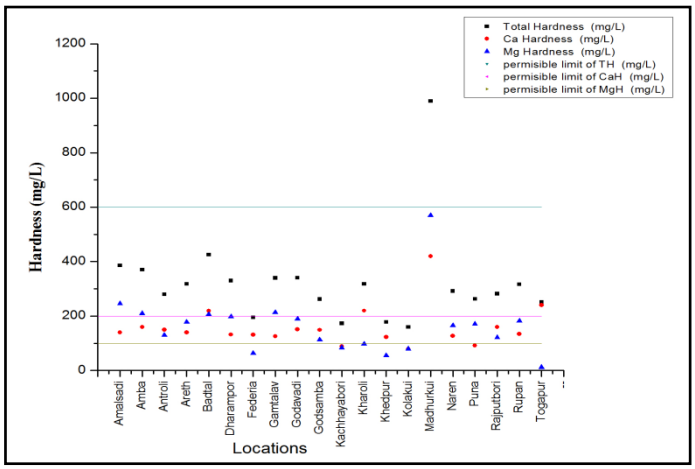

Figure 6 Hardness concentration at Mandvi Taluka

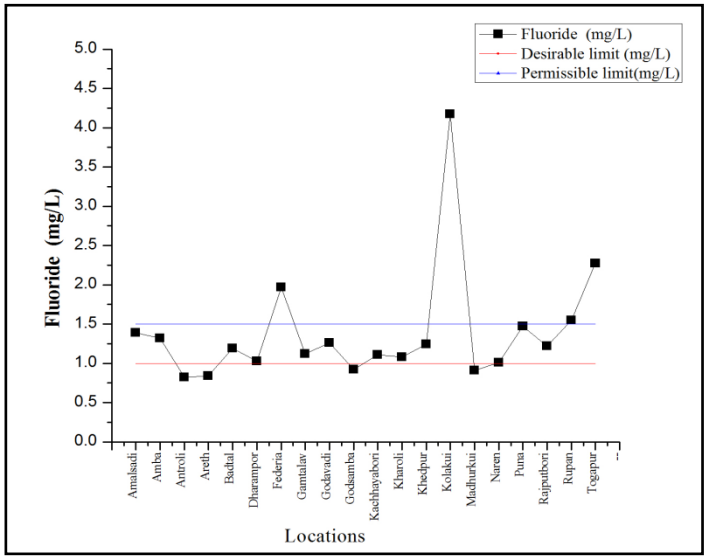

Figure 7 Fluoride ion concentrations at Mandvi Taluka

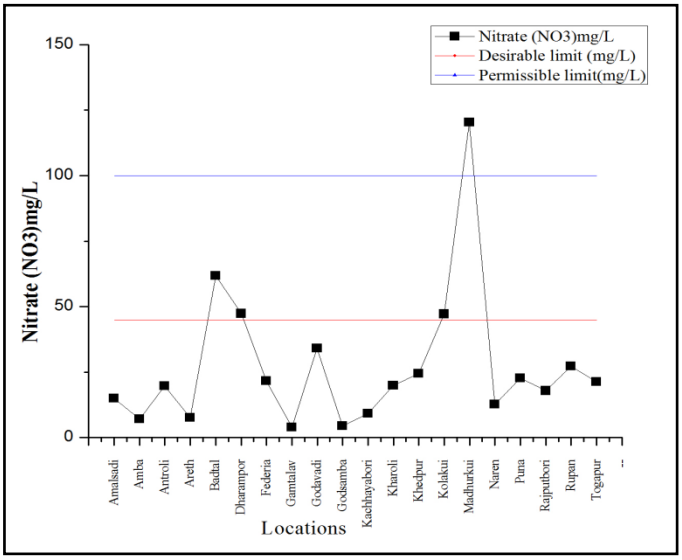

Figure 8 Nitrate ion concentration at Mandvi Taluka

Electrical conductivity (EC) measures the electrical current, which is proportional to the minerals present in water. Variation in EC was recorded in all samples. EC values ranged from 493.5 µs/cm (Federia) to 1902 µs/cm (Madhurkui). The high EC values may be due to the rock soils and the presence of higher TDS in the study areas (Rao et. al., 2004; Figure-2). The chloride content also varied in the range of 38.98 mg/L to 391.87 mg/L, Only two water samples is having the higher chloride content i.e. Amba and Madhurkui. High chloride content in drinking water gives a salty taste. Association of salinity, with high fluoride waters is a general concept. The primary source of fluoride in groundwater being weathering of rocks, dissolution of fluoride with other salts and hence extra build of salinity in high fluoride waters could be a natural phenomenon (Gupta, 1999, figure-4). While Sulphates (SO_4^{2-}) ranges from 14.92 mg/L to 494.07 mg/L. Health concerns regarding sulphate in drinking water have been raised due to the reports that diarrhea may be associated with the ingestion of water containing high levels of sulphate. The variation of Sulphate in the study is shown figure 5.

However, total hardness (160 mg/L to 990 mg/L) of all the studied samples except four locations i.e. federia, kacchayabori, khedpur and kolakui was exceeding the permissible limits. According to Durfor and Becker, 1964 classification of water types based on total hardness, all the total 20 samples are under very hard categories (Figure-6). Calcium ions (Ca^{2+}) concentration shows wide variation from minimum of 80 mg/L to as high as 420 mg/L. Total four villages(Badtal, Kharoli, Madhurkui and Togapur) exceeds the acceptable limit of 200 mg/L as per the BIS standard. The Magnesium ion (Mg^{2+}) concentration varies from 12 mg/L to 570 mg/ Total 6 villages exceeds the acceptable limit of 100 mg/L as per the Indian standard.

The data revealed considerable variations in the water samples with respect to fluoride. From the studied available data, groundwater concentration is shown to be highly variable and variations are seen between different villages within the same block. The fluoride concentration in the groundwater was found to vary between 0.82 to 4.17mg/L;16 samples out of the total 20 samples analyzed exceeds the desirable limit of 1mg/L as per the Indian standard, whereas 4 samples exceed the permissible limit of 1.5 mg/L as recommended by WHO and BIS. Fluoride affected groundwater is found to occur more in the Northern part of the study (Figure-7).

The Nitrate (NO_3^-) content ranges from negligible amount 3.89 mg/L to 120.42 mg/L. Nitrate content of Badtal, Dharampor, Kolalkui and Madhurkui was higher mainly due to the agricultural fields where the nitrogenous fertilizers make their entry into ground waters due to leaching. The poor sanitation level is also another important source contributing high amount of nitrate in ground water (Chaudhary et.al. 2007, Kataria, 2012; figure-8). Total dissolved solids level in ground water is 422.5-1310 mg/L which exceeds the permissible limit of 500 mg/L as per Indian standards and 2000 mg/l as per WHO Standards. The term total dissolved solids refer mainly to the inorganic substances that are dissolved in water. The effects of TDS on drinking water quality depend on the levels of its individual components; excessive hardness, taste, mineral depositions and corrosion are common properties of highly mineralized water.

6. CONCLUSIONS

The main objective of the present study was to understand and analyze the quality of groundwater in and around Mandvi Taluka, Surat District, Gujarat, India. The study reveals that most of the samples are Alkaline and very hard in nature. From the studied available data, groundwater concentration is shown to be highly variable and variations are seen between different villages within

the same block. The fluoride concentration in the groundwater was found to vary between 0.82 to 4.17mg/L. It has been also observed that that fluoride contamination was found in 16 locations of Mandvi Taluka. The Fluoride contamination was up to the 4.17mg/L concentration from kolakui village, Mandvi Taluka. Moreover, Majority of the samples do not comply with Indian as well as WHO standards for most of the water quality parameter. Overall water quality was found as unsatisfactory for drinking purposes without any prior treatment.

REFERENCE

1. Adriano, D.C., 1986.Trace Elements in the terrestrial Environment. Springer-Verlag, New York
2. Apambire, W.B.; Boyle, D.R. and Michel, F.A.; 1997, Geochemistry, genesis and health implication of floriferous groundwater in the upper regions, Ghana, Environment Geology, 33:13-24.
3. Boyle, D.R. and Chagnon, M., 1995. An incidence of skeletal fluorosis associated with groundwater of the Maritime Carboniferous Basin Gaspe Region, Quebec, Canada. Environ. Geochem Health, 17:5-12.
4. Chaudhary, P., Dagaonkar, A. and Praveen, S. 2007. Physico-chemical analysis of ground waters for
5. Evaluation of Drinking water quality at Dhar Town, Madhya Pradesh. Nature Environment and Pollution Technology. 6(1): 109-112.
6. Durfor, C.N. and Becker, E., 1964. Public water supplies of the 100 largest cities in United States. U.S.Geological Survey, water supply paper 1812:364.